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Decker

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(54) **SYSTEM AND METHOD FOR A HYBRID TOPOLOGY MEDIA CONFERENCING SYSTEM**

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H04N 19/40 (2014.01)
H04L 29/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H04N 7/152*** (2013.01); ***H04L 65/00*** (2013.01); ***H04N 19/40*** (2014.11)

(58) **Field of Classification Search**
USPC 348/14.09
See application file for complete search history.

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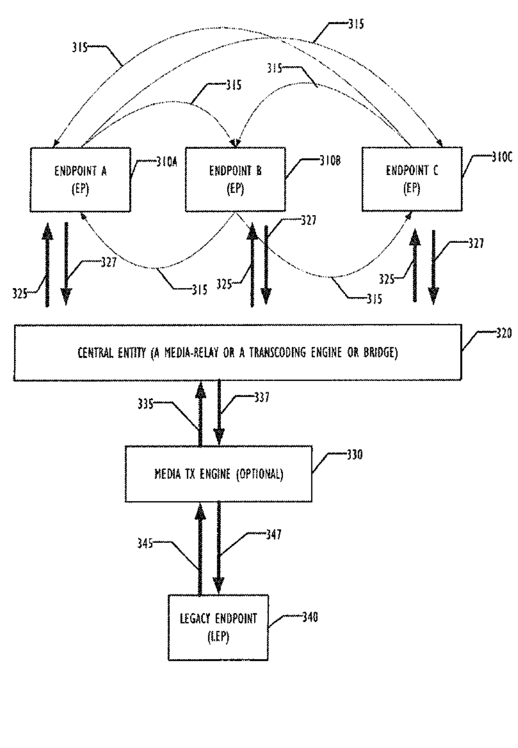
(57) **ABSTRACT**

Examples hybrid topologies of a conferencing system are disclosed. An example of a hybrid topology may comprise a plurality of endpoints and a central entity. Each of said plurality of endpoints may provide its primary video stream and audio stream to said centralized entity. The centralized entity provides the primary speaker stream and the mixed audio stream to each of said plurality of endpoint participants. In addition, some of plurality of endpoint establishes low bandwidth/low resolution media streams with other of said plurality of endpoint participants for non-speaker video.

12 Claims, 7 Drawing Sheets



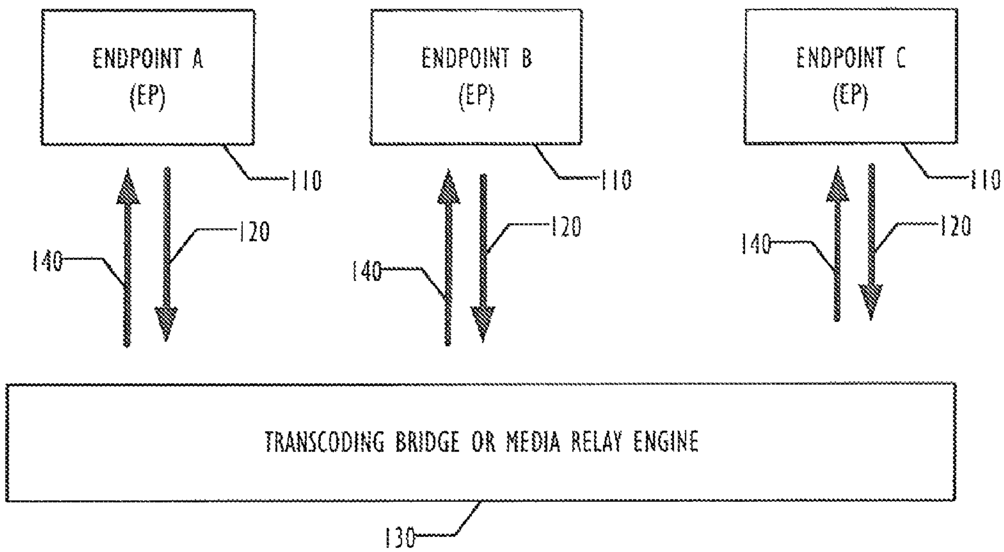


Fig. 1
(Prior Art)

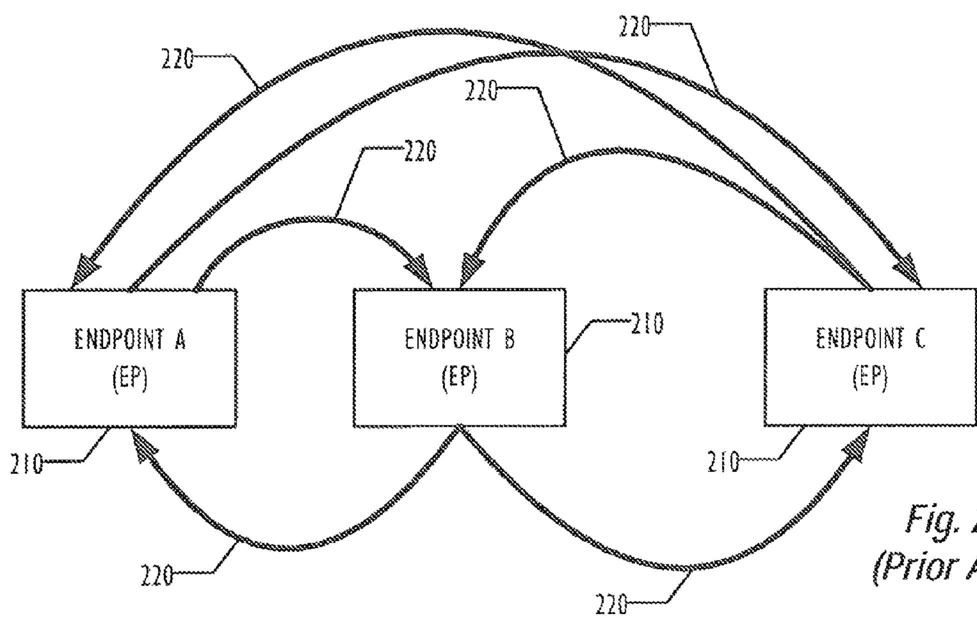


Fig. 2
(Prior Art)

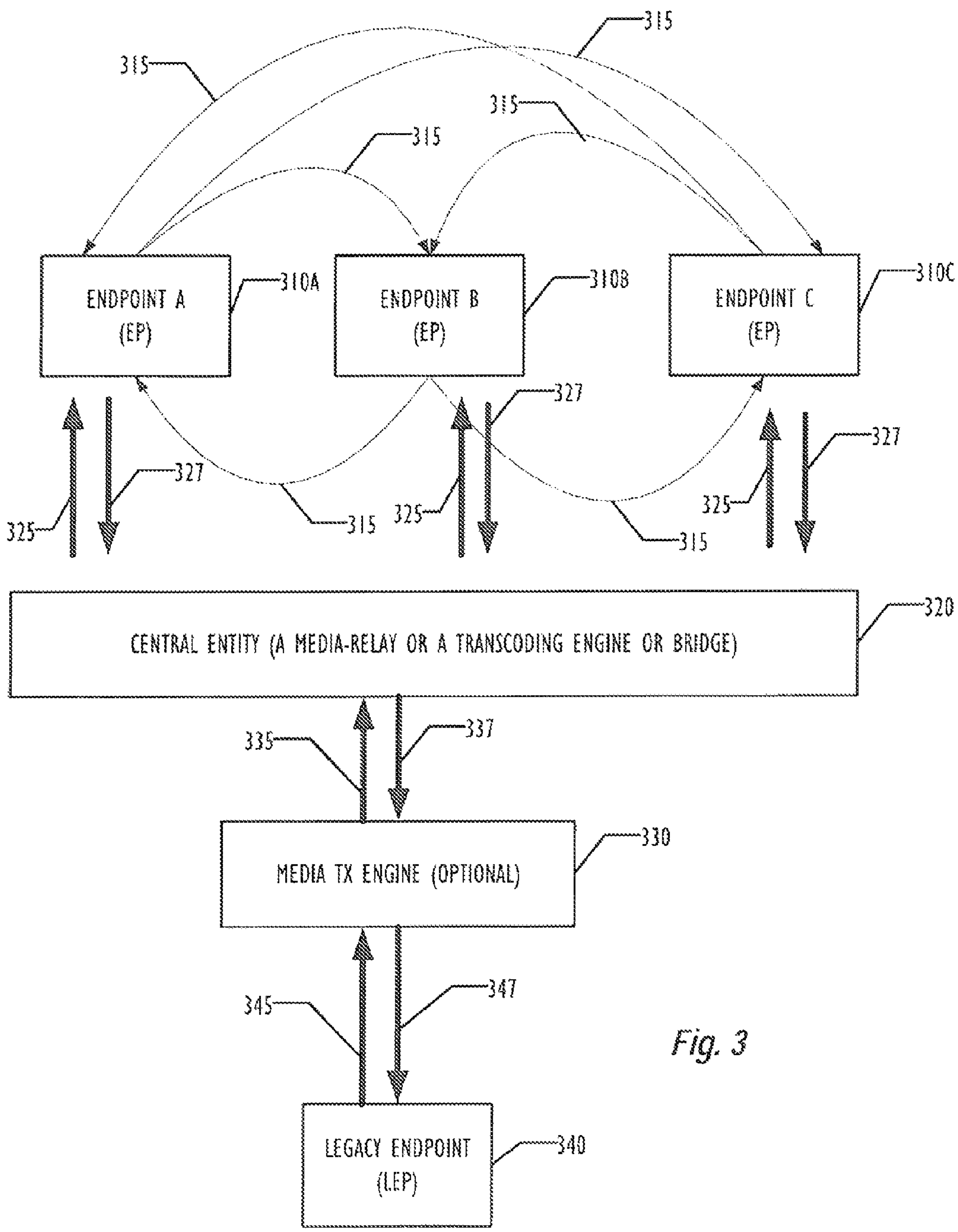

315
315
315
315
ENDPOINT A
(EP)
310A
ENDPOINT B
(EP)
310B
ENDPOINT C
(EP)
310C
327
327
327
325
315
325
325
315
CENTRAL ENTITY (A MEDIA-RELAY OR A TRANSCODING ENGINE OR BRIDGE)
320
335
337
MEDIA TX ENGINE (OPTIONAL)
330
345
347
LEGACY ENDPOINT
(LEP)
340

Fig. 3

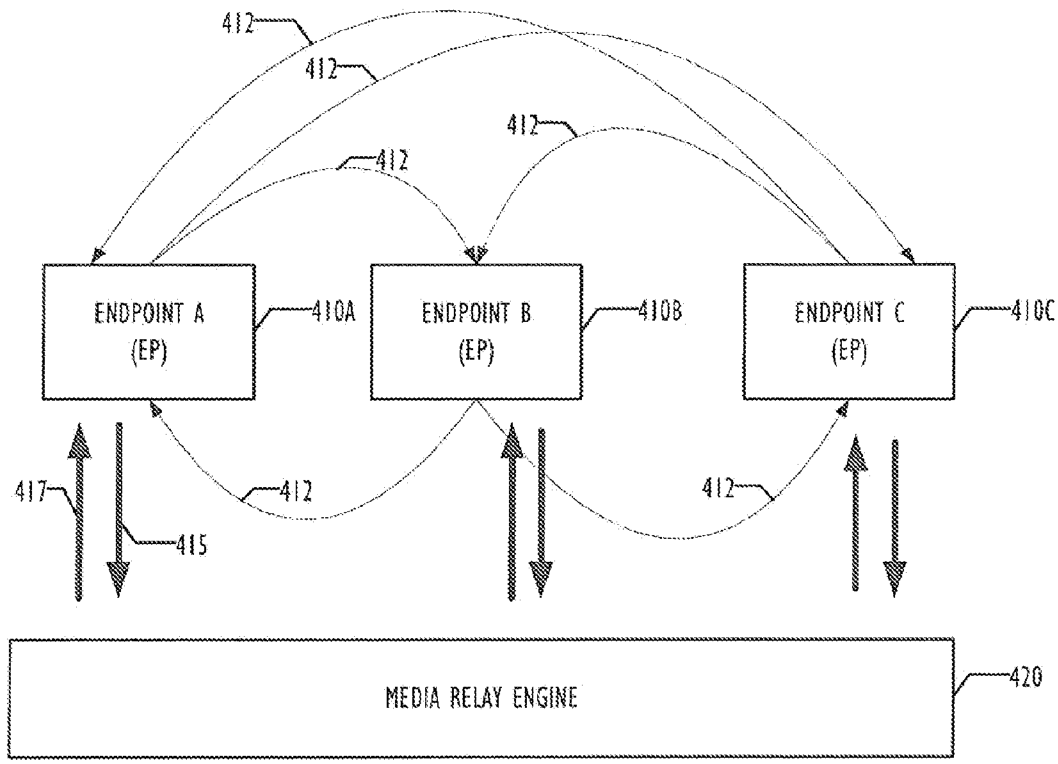
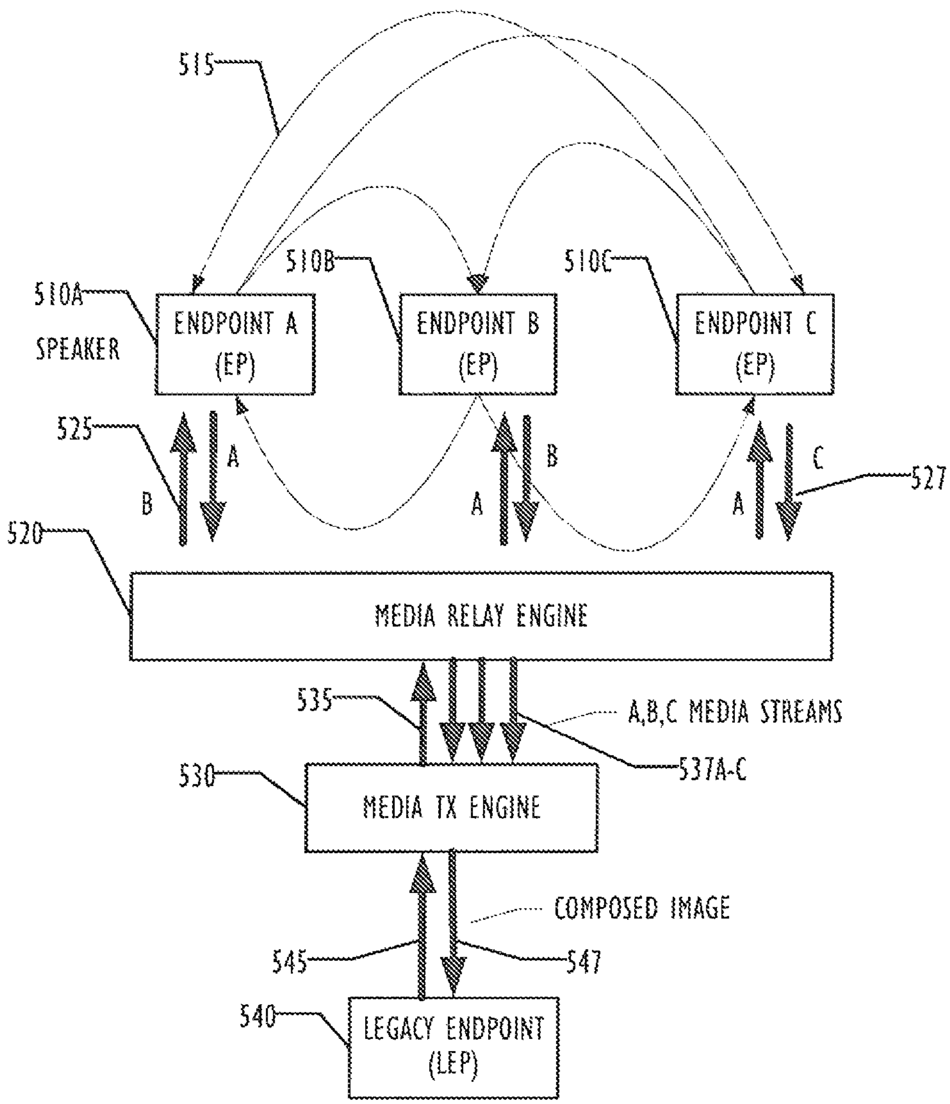

412
412
412
412
ENDPOINT A
(EP)
410A
ENDPOINT B
(EP)
410B
ENDPOINT C
(EP)
410C
417
415
412
412
MEDIA RELAY ENGINE
420

Fig. 4



515
510A
SPEAKER
ENDPOINT A
(EP)
510B
ENDPOINT B
(EP)
510C
ENDPOINT C
(EP)
525
B
A
A
B
A
C
527
520
MEDIA RELAY ENGINE
535
A,B,C MEDIA STREAMS
537A-C
530
MEDIA TX ENGINE
COMPOSED IMAGE
545
547
540
LEGACY ENDPOINT
(LEP)

Fig. 5

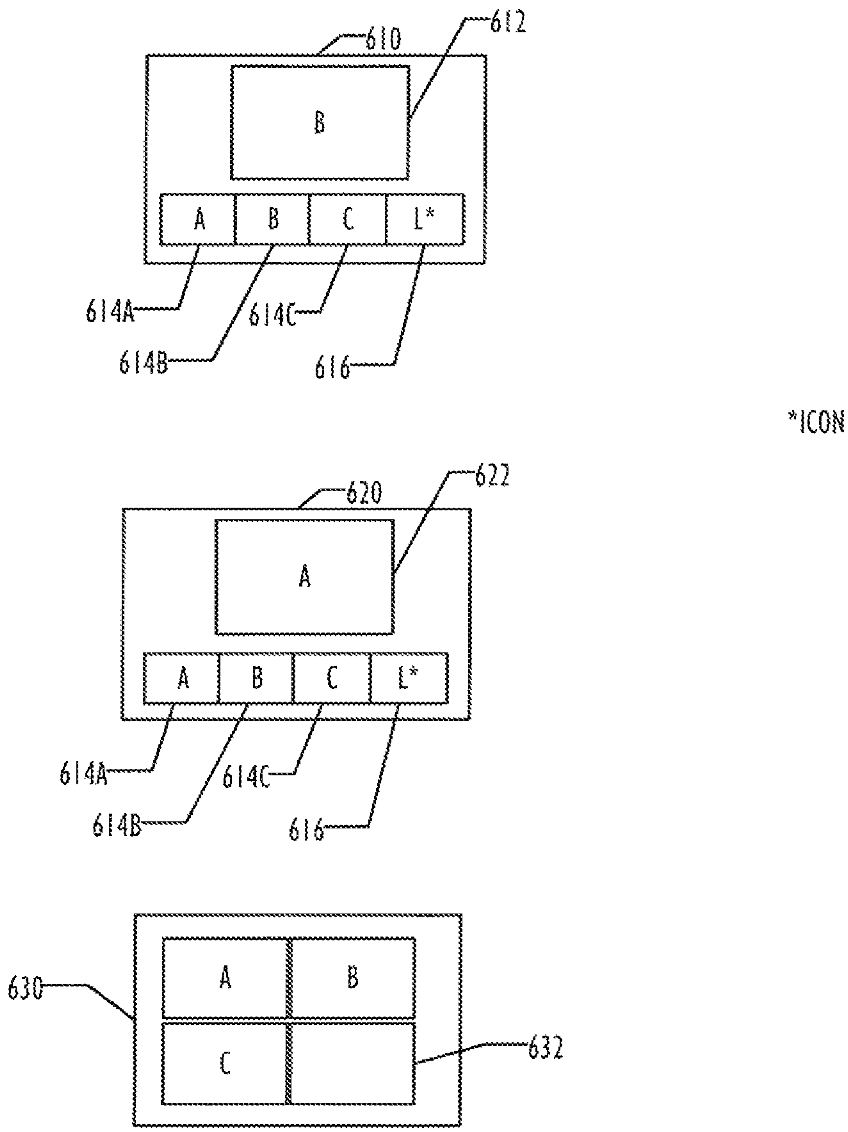

610
612
B
A
B
C
L*
614A
614B
614C
616
*ICON
620
622
A
A
B
C
L*
614A
614B
614C
616
630
A
B
C
632

Fig. 6

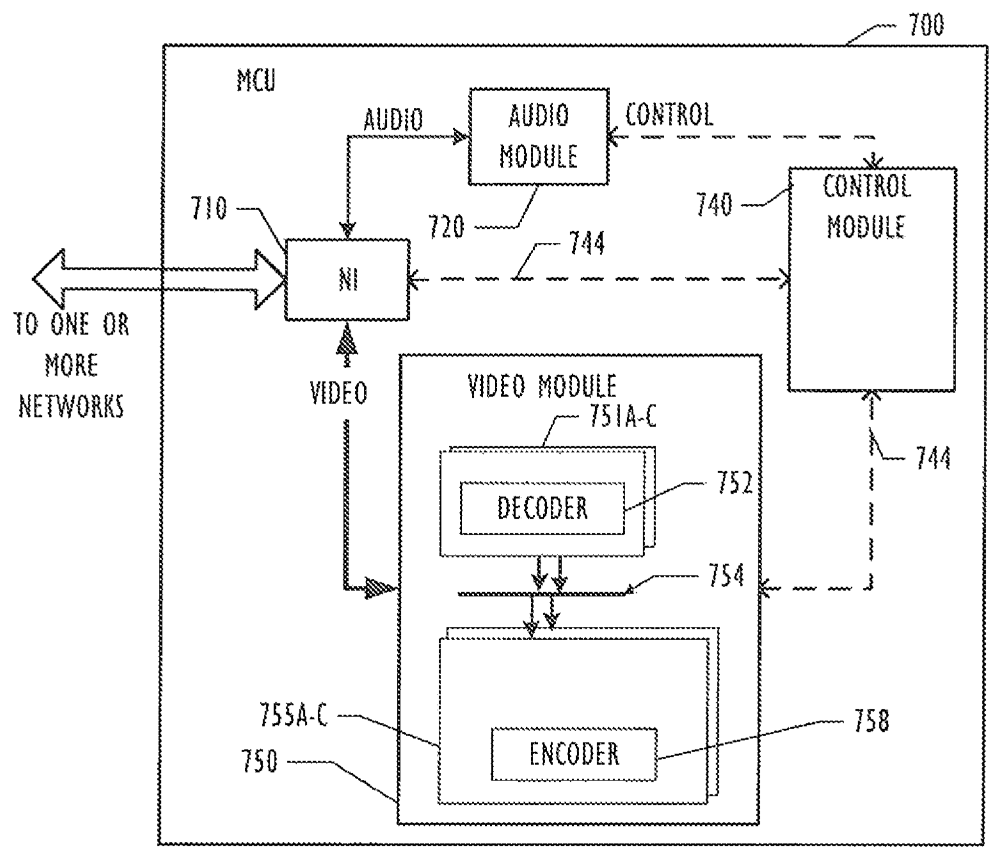

700
MCU
AUDIO
AUDIO MODULE
CONTROL
710
720
740
CONTROL MODULE
744
NI
TO ONE OR MORE NETWORKS
VIDEO
VIDEO MODULE
751A-C
744
752
DECODER
754
755A-C
758
ENCODER
750

FIG. 7

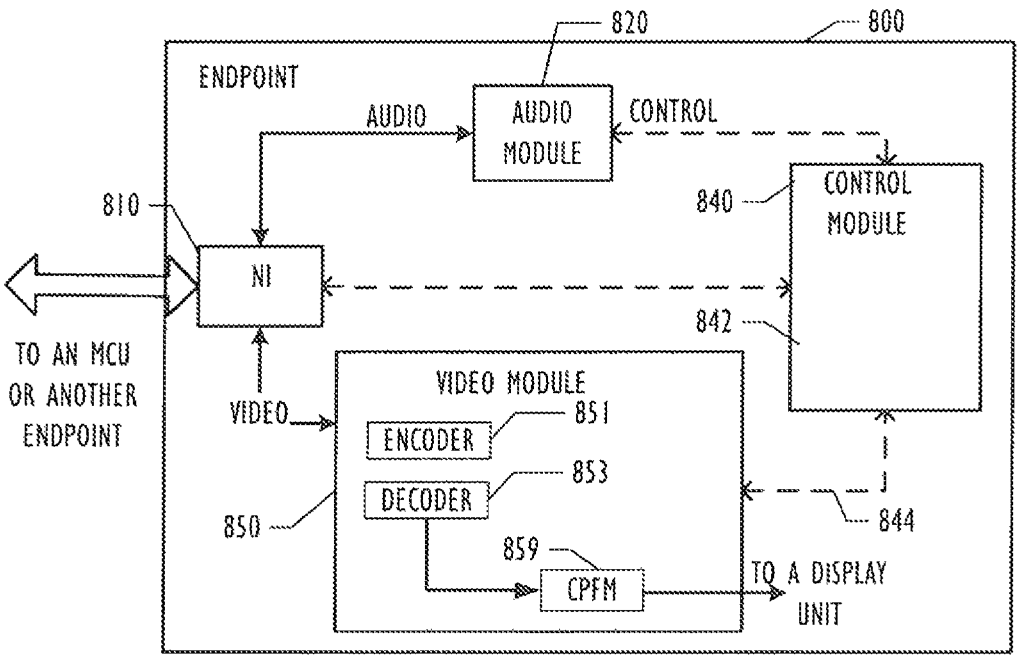

820
800
ENDPOINT
AUDIO
AUDIO MODULE
CONTROL
810
840
CONTROL MODULE
NI
842
TO AN MCU OR ANOTHER ENDPOINT
VIDEO MODULE
VIDEO
ENCODER
851
DECODER
853
850
844
859
CPFM
TO A DISPLAY UNIT

FIG. 8

SYSTEM AND METHOD FOR A HYBRID TOPOLOGY MEDIA CONFERENCING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to conferencing systems.

2. Description of the Related Art

As every day applications and services migrate to Internet Protocol (IP) networks at a remarkable rate, and with the growth of the variety of multimedia conferencing equipment, more and more people use multimedia conferencing as their communication tool. Today multimedia conferencing communication can be carried using a plurality of conferencing techniques. Following are few examples of conferencing techniques: the AVC multimedia conferencing method and the media relay conferencing method. AVC stands for Advanced Video Coding. In this disclosure, the terms: multimedia conference, video conference (with or without content) and audio conference may be used interchangeably and the term video conference can be used as a representative term of them.

Usually an AVC multipoint conference between three or more participants requires a AVC Multipoint Control Unit (MCU). An AVC MCU is a conference controlling entity that is typically located in a node of a network or in a terminal which receives several channels from a plurality of endpoints. According to certain criteria, the AVC MCU processes audio and visual signals and distributes them to each of the participating endpoints via a set of connected channels. Examples of AVC MCUs include the RMX® 2000, which are available from Polycom, Inc. (RMX is a registered trademark of Polycom, Inc.) A terminal in the AVC-communication method, which may be referred to as a AVC endpoint (AVCEP), is an entity on the network, capable of providing real-time, two-way audio and/or audio visual communication with another AVCEP or with the MCU. A more thorough definition of an AVCEP and an MCU can be found in the International Telecommunication Union ("ITU") standards, such as but not limited to the H.320, H.324, and H.323 standards, which can be found at the ITU Website: www.itu.int.

A common MCU, referred to also as a AVC MCU, may include a plurality of audio and video decoders, encoders, and media combiners (audio mixers and/or video image builders). The MCU may use a large amount of processing power to handle audio and video communication between a variable number of participants (AVCEPs). The communication can be based on a variety of communication protocols and compression standards and may involve different types of AVCEPs. The MCU may need to combine a plurality of input audio or video streams into at least one single output stream of audio or video, respectively, that is compatible with the properties of at least one conferee's AVCEP to which the output stream is being sent. The compressed audio streams received from the endpoints are decoded and can be analyzed to determine which audio streams will be selected for mixing into the single audio stream of the conference. Along the present disclosure, the terms decode and decompress can be used interchangeably.

A conference may have one or more video output streams wherein each output stream is associated with a layout. A layout defines the appearance of a conference on a display of one or more conferees that receive the stream. A layout may be divided into one or more segments where each segment may be associated with a video input stream that is sent by a certain conferee via his/her AVCEP. Each output stream may

be constructed of several input streams, resulting in a continuous presence (CP) image. In a CP conference, a user at a remote terminal can observe, simultaneously, several other participants in the conference. Each participant may be displayed in a segment of the layout, where each segment may be the same size or a different size. The choice of the participants displayed and associated with the segments of the layout may vary among different conferees that participate in the same session.

The second type of communication method is Media Relay Conferencing (MRC). In MRC, a Media Relay MCU (MRM) receives one or more streams from each participating Media Relay Endpoint (MRE). The MRM relays to each participating endpoint a set of multiple media streams received from other endpoints in the conference. Each receiving endpoint uses the multiple streams to generate the video CP image, according to a layout, as well as mixed audio of the conference. The CP video image and the mixed audio are played to MRE's user. An MRE can be a terminal of a conferee in the session which has the ability to receive relayed media from an MRM and deliver compressed media according to instructions from an MRM. A reader who wishes to learn more about an example of an MRC, MRM or an MRE is invited to read the U.S. Pat. No. 8,228,363, which is incorporated herein by reference. In the following, the term endpoint may represent also an MRE.

In some MRC systems, a transmitting MRE sends its video image in two or more streams; each stream can be associated with different quality level. The qualities may differ in frame rate, resolution and/or signal to noise ratio (SNR), etc. In a similar way each transmitting MRE may sends its audio in two or more streams that may differ from each other by the compressing bit rate, for example. Such a system can use the plurality of streams to provide different segment sizes in the layouts, different resolution used by each receiving endpoint, etc. Further, the plurality of streams can be used for overcoming packet loss.

Today, MRC becomes more and more popular. Many video conferencing systems deliver a plurality of quality levels in parallel within one or more streams. For video, for example, the quality can be expressed in number of domains, such as temporal domain (frames per second, for example), spatial domain (HD versus CIF, for example), and/or in quality (sharpness, for example). Video compression standards, for example, that can be used for multi quality streams are H.264 AVC, H.264 annex G (SVC), MPEG-4, etc. More information on compression standards such as H.264 can be found at the ITU Website www.itu.int, or at www.mpeg.org.

H.323 is an ITU standard. A reader who wishes to learn more about video conferencing standards and protocols is invited to visit the International Telecommunication Union ("ITU") at the ITU Website: www.itu.int or at the Internet-Engineering-Task Force (IETF) Website: www.ietf.org. AVC multipoint conference system, MRC, MCU, an AVC endpoint, MRE, a Web conferencing client, and a VMR are well known to a person with ordinary skill in the art and have been described in many patents, patent applications and technical books. As such these will not be further described. Following are examples of patents and patent applications that describe videoconferencing systems: U.S. Pat. Nos. 6,496,216, 6,757,005, 7,174,365, 7,085,243, 8,411,595, 7,830,824, 7,542,068, 8,340,271, 8,228,363, and others.

In the two types of communication methods, the AVC and the MRC, a central entity is needed for handling signaling and the media streams (audio, video), an MCU or an MRM (respectively), for example. In order to establish a video conferencing system an endpoint can call a central unit such as an

MCU or a virtual MCU. A virtual MCU (VMCU) can be a network device, a control server for example, that can communicate with a plurality of MCUs and a plurality of endpoints. A user initiates a reserve conference and/or an ad-hoc conference can communicate with the VMCU. If sufficient resources are available on one or more MCUs, the reservation is made and connection numbers are assigned. When the time for the conference arises, one or more MCU are assigned to the conference and the participants are then be connected to the conference. A reader who wishes to learn more about a VMCU is invited to read a plurality of patents and patent applications such as U.S. Pat. Nos. 7,174,365, 7,492,730, and many others. An example of a VMCU can be a product such as a DMA® sold by Polycom Inc. (DMA is a registered trademark of Polycom, Inc.)

After establishing the session each endpoint sends its media streams to an MCU or an MRM. The MCU or the MRM process the media stream according to the type of the communication methods and transfers the relevant streams to receiving endpoints. Along the description and the claims the term MCU can be used as a representative term for an MRM and a AVC MCU.

An MCU may comprise a Multipoint-Controller (MC) and a Multipoint-Processor (MP). The MC can be a packet-switch (SW) network entity that is located at the network that provides the signaling and control of three or more terminals participating in a multipoint conference. An example of packet SW network can be an IP network. The MC may also connect two terminals in a point-to-point conference, which may later develop into a multipoint conference. The MC provides capability negotiation with all terminals to achieve common levels of communications, and may also control conference resources. The MC signaling and control can be implemented by using a standard signaling protocol such as SIP. SIP stands for Session Initiation Protocol. A reader who wishes to learn more about SIP is invited to visit the IETF (Internet Engineering Task Force) web site: www.ietf.org. However, the MC does not perform mixing or switching of audio, video and data. The Multipoint Processor (MP) is a media entity on the network providing the centralized processing of audio, video, and/or data streams in a multipoint conference.

The MP provides the media processing such as decoding, mixing, composing, encoding, switching, routing or other processing of media streams under the control of the MC. The MP may process a single media stream or multiple media streams depending on the type of conference supported. A single MC can control a plurality of MPs.

Two common topologies are used in support of multi-point conferencing today:

1) Centralized Topology (FIG. **1**): with this method, all participants **110** send one or more media streams **120** up to a central media processing entity **130**, and each receives one or more streams **140** from the same centralized entity **130**. The streams **120** transmitted upstream to the centralized entity **130** can include one or more local camera feeds and one or more content feeds. The streams **140** transmitted back from the centralized entity **130** are rendered on screen and shown to the participant. When using a centralized approach, two flavors are used today:

A. Transcoding: where the central entity **130** transcodes all incoming and outgoing streams, typically using an MCU such as an AVC MCU. With this approach the centralized entity consumes a lot of compute resources per participant. This becomes an issue for scale and the budget needed for allocating such resources.

B. Media Relay: where the centralized entity **130**, typically an MRM, relays all incoming and outgoing streams. With current relay deployments, the centralized entity **130** receives one or more streams **120** from each participant **110**, and sends multiple streams **140** back down to that participant **110**, so the participant **110** can see the other participants **110** in the call. This means that all media must flow through a single entity, which could become a bottleneck.

2) Mesh Topology (FIG. **2**): with this method, streams **220** are sent peer-to-peer between the participants **210**. Each participant **210** sends a copy of its stream(s) to each of the other participants **210** and receives media stream(s) from each other participant **210** in the session.

Each method carries its own limitations. Centralized topology sessions depend on heavy lifting media transcoding resources which are expensive and have scaling limitations. Mesh topology sessions require a good deal of CPU on each endpoint **210** for processing the streams being sent and received, and the total the amount of bandwidth required by each participant can also be substantial in order to have a successful experience.

SUMMARY OF THE INVENTION

In a hybrid topology, each participant delivers, in parallel, multiple media streams: a primary video stream with a higher resolution/bandwidth and additional streams having lower resolution/bandwidth.

Each participant provides its primary video stream, audio stream, and optionally one or more content streams to a centralized entity. It also provides low bandwidth/low resolution video streams to the other participants. Each participant receives the primary speaker's or speakers' stream(s), optional content stream(s) and the mixed audio stream from the centralized entity. In addition, each participant receives one or more low bandwidth/low resolution video streams from the other participants.

BRIEF DESCRIPTION OF THE FIGURES

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate an implementation of apparatus and methods consistent with the present invention and, together with the detailed description, serve to explain advantages and principles consistent with the invention.

FIG. **1** illustrates a conferencing system according to the prior art using a centralized entity.

FIG. **2** illustrates a conferencing system according to the prior art using peer to peer communications.

FIG. **3** illustrates a first embodiment of a hybrid topology conferencing system.

FIG. **4** illustrates a second embodiment of a hybrid topology conferencing system.

FIG. **5** illustrates a third embodiment of a hybrid topology conferencing system.

FIG. **6** illustrates examples of possible layouts presented by some endpoints at a certain point in time according to one embodiment.

FIG. **7** is a block diagram illustrating components of a centralized entity according to one embodiment.

FIG. **8** is a block diagram illustrating components of an endpoint according to one embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments according to the present invention use a hybrid approach in which participants use mesh and centralized topologies at the same time, gaining benefits over using just one or the other.

An example of a hybrid topology is shown in FIG. **3**, in which mesh endpoints **310**A-C communicate between themselves via mesh connections **315** while at the same time they communicate with a centralized entity **320**, while one or more legacy endpoints **340** communicate with a centralized entity **320** via a media transcoding engine **330**.

Video Handling

As each participant **310** joins the session, each participant **310** sends its main video feed (e.g., its camera source) and optionally one or more content feeds **327** upstream to a centralized entity **320** that could be either a media-relay or a transcoding engine or bridge. The centralized entity **320**, in turn, sends back a high resolution/bandwidth video stream **325** of the active speaker and one or more content streams, if any exist. In some embodiments, the centralized entity **320** may return multiple streams **325** representing a plurality of subset of active speakers and one or more content streams. The structure and functionality of the central entity **320** is known to the art.

Each participant **310** also establishes mesh connections **315** with the other participants **310** to send and receive video of non-speakers only. These are low resolution/low bitrate connections **315**.

In some embodiments, legacy endpoint **340** may connect to the conference session through a media transcoding engine **330** that connects to the central entity **320**, sending a video stream **345** to the media transcoding engine **330**, which transcodes the stream into transcoded stream **335** and sends transcoded stream **335** to the central entity **320**. Similarly, the central entity **320** may send back a high resolution/bandwidth video stream **337** to the transcoding engine **330**, which transcodes the video stream **337** and sends transcoded video stream **347** to the legacy endpoint **340**. The media transcoding engine **330** is optional and can be omitted where transcoding is unnecessary or can be performed by the central entity **320**. Multiple legacy endpoints may be connected via the media transcoding engine **330** in some embodiments, or may connect directly to the central entity **320** as desired.

Audio Handling

In one embodiment, as each participant joins the session, each participant **310** sends its main audio feed **327** (e.g., its microphone source) upstream to the centralized entity **320** that could be a media-relay or a transcoding engine or bridge. The centralized entity **320**, in turn, sends back an audio mix **325** of all (or a selected subset of) the conference participants **310**. In this embodiment, audio streams are not sent via meshed connections among the participants **310**. In an embodiment which does not use a media transcoding engine **330**, the central entity **320** may transcode the audio streams as necessary in order to send the audio streams as streams **337** to legacy endpoints **340**. In some embodiments, the central entity **320** may mix the audio streams **327** into a single audio stream **337** for delivery to either the media transcoding engine **330** or to the legacy endpoint **340**. In other embodiments, either the transcoding engine **330** or the legacy endpoint **340** may perform the audio mixing.

In an alternate embodiment, each participant **310** sends its main audio feed (e.g., its microphone source) to each of the other participants **310** in the call via the mesh connections **315**. Each of the participants **310** in the call performs a local mix of the audio streams that participant **310** receives via the mesh connections **315**. In addition, each participant **310** sends its main audio feed upstream as stream **327** to the centralized entity **320**. The centralized entity **320** sends the audio streams as streams **337** toward a media transcoding engine **330**. The media transcoding engine **330** sends an audio mix **347** of all (or selected subset of) the conference participants to one or more legacy endpoints **340**. The legacy endpoint **340** sends its audio stream **345** to the Media transcoding engine **330** for sending to the central entity **320**, which then delivers that audio stream to the meshed participants **310** as streams **325**.

The Media transcoding engine **330** can transcode the media streams, signaling, and control needed in order to connect to the legacy endpoint with the centralized entity **320**. A reader who wish to learn more about the media transcoding engine **330** is invited to read U.S. Pat. No. 8,228,363 or U.S. Pa. Pub. No. 20140028788, the content of which are incorporated herein by reference.

Example Use Cases

FIG. **4** illustrates the case where all participants **410** use compatible codecs. Each participant **410** sends its main video feed (e.g., its camera source) and optionally one or more content feeds **415** upstream to a centralized entity **420**. The centralized entity **420**, in turn, sends back a high resolution/bandwidth video stream **417** of the active speaker and the content stream(s), if they exist. Where there are multiple active speakers, the centralized entity **420** may return multiple streams **417** representing the subset of active speakers in some embodiments. Each participant **410** establishes mesh connections **412** with the other participants **410** to send and receive video of non-speakers only. These are low resolution/low bitrate connections **412**.

All participants **410** have available compatible audio and video codecs and elect to use them. In this case, we can use media-relay at the central entity **420**. In some embodiments, the central entity **420** can mix the audio streams of all or selected participants but do not need to transcode any video streams.

FIG. **5** illustrates the case where some of the participants use non-compatible codecs. In the illustrated example, a legacy endpoint **540** may use a different codec for audio or video than the other endpoints **510** in the session. Each participant **510** sends its main video feed (e.g., its camera source) **527** and optionally one or more content feeds upstream to a centralized entity **520**. In this example, the centralized entity **520** transcodes the video for the active speaker coming from one or more legacy endpoints **540** and mixes the audio streams of all participants **510**. The centralized entity **520** sends high resolution video for the active speaker to the endpoints **510** in streams **525**. The endpoints **510** use mesh connections **515** for sending low bandwidth/load bitrate video between the endpoints **510**.

The centralized entity **520** sends the media streams **537**A-C toward a media transcoding engine **530**. The media transcoding engine **530** sends a composed media stream **547** that contains an audio mix of all (or a selected subset of) the conference participants **510**, a composed video image, and optionally one or more content streams. The composed media stream **547** is transferred to one or more legacy endpoints **540** to be rendered to the user of the one or more legacy endpoints **540**. In the other direction, the legacy endpoint **540** sends its media streams **545**, including audio, video, and content, if any, to the media transcoding engine **530**, which in turns sends streams **535** to the centralized entity **520**, typically a media relay engine for delivery as streams **525** to the other endpoints **510**.

In addition, FIG. **6** illustrates examples of possible layouts **610**, **620**, and **630** presented by some endpoints at a certain point in time. Example layout **610** represents a layout that may be shown to user of endpoint **510**A, which is the current speaker. In this example, main segment **612** displays video from endpoints **510**B, the previous speaker, instead of showing the self-image of participant **510**A.

Example layout **620** represents a layout that would be shown to user of endpoint **510**B or **510**C, which are not the current speaker. In this example, main segment **622** displays video from endpoint **510**A, the current speaker.

Example layout **630** represents a layout that would be shown to user of legacy endpoint **540**, which each of endpoints **510**A, **510**B, and **510**C displayed in a 2×2 arrangement, with segment **632** being empty.

In the examples illustrated in FIG. **6**, each of layouts **610**, **620** is showing participants **510**A, **510**B, and **510**C as segments **614**A, **614**B, and **614**C, while the legacy endpoint **540** is represented by an icon **616**. In some embodiments, the icon **616** may be a still image of the user of legacy endpoint **540**. In other embodiments, the icon **616** can be a graphical representation of the user, or a text displaying the name of the user of legacy endpoint **540**, the name of the site where endpoint **540** is located, or any other graphical representation. The icon image **616** may be obtained, for example, from a memory device (not shown) which can be connectively coupled with each of the endpoints **510**.

In the examples illustrated in FIG. **6**, each of layouts **610**, **620** is showing a self-image of participants **510**A, **510**B, and **510**C. In another embodiment, each of the layouts **610**-**630** may exclude the self-image of the relevant participant, for example in the layout **610** for endpoint **510**A, the segment **614**A may be excluded, displaying only segments **614**B, **614**C, and **616**.

Some of the benefits of the hybrid approach include:

1. In comparison to the full mesh approach, with the hybrid topology each participant needs to send and receive only one single high resolution/high bandwidth media stream, and process only a single audio stream. Full mesh topology requires a participant's endpoint to send N−1 (with N the number of participants in the session) high resolution/high bandwidth streams when that participant becomes the speaker. Thus, the hybrid approach reduces the bandwidth consumption.

2. In comparison to the fully-transcoded centralized topology approach, the hybrid topology method uses much less compute resources. That is, the centralized entity is only required to relay the speaker media and perform the audio mixing. This requires much less processing resources than having all incoming and outgoing audio and video streams requiring transcoding.

FIGS. **7**-**8** are block diagrams that illustrate relevant elements of example embodiments of a centralized entity **700** (in this example, an MCU) and an endpoint **800**. Centralized entity **700** is capable of implementing aspects of the disclosed methods for controlling a hybrid topology media conferencing system. An example embodiment of centralized entity **700** may comprise one or more processors, computer readable medium such as a read/write hard disc, CDROM, Flash memory, ROM, or other memory or storage devices, etc. Software of a logical module may be embodied on one of the computer readable medium. In order to execute a certain task, a software program may be loaded to an appropriate processor as needed.

Centralized entity **700** may include a network interface module (NI) **710**, an audio module **720**, a control module **740** and a video module **750**. The network interface module **710** receives communication from a plurality of endpoints via one or more networks (not shown in the figures). Network interface **710** processes the communication according to one or more variety of communication standards such as but not limited to H.320, H.323, SIP, etc. and compression standards such as H.261, H.263, H.264, G711, G722; MPEG etc. Network interface **710** can receive and transmit control and data information to/from other centralized entities **700** and endpoints **800**. More information concerning the communication between the endpoint and the centralized entity **700** over the relevant network and information that describing signaling, control, compression, and setting a video call can be found in the international telecommunication union (ITU) standards H.320, H.321, H.323, H.261, H.263 and H.264 or SIP.

Network interface module **710** multiplexes/de-multiplexes the different signals, media and/or "signaling and control," that are communicated between the endpoints and the centralized entity **700**. The compressed audio signal is transferred to and from the audio module **720**. The compressed video signal is transferred to and from video module **750** and the "control and signaling" is transferred to and from control module **740**.

Audio module **720** may receive, via network interface **710** and the audio line, compressed audio streams from the plurality of endpoints. The audio module **720** decodes the compressed audio streams, analyzes the decoded streams, selects certain streams and mixes the selected streams. Then the mixed stream is compressed and the compressed audio stream is sent via the audio line back to the network interface **710** which sends the compressed audio streams to the different endpoints. Audio streams that are sent to different endpoints can be different. For example the audio stream can be formatted according to the different communication standard and according to the needs of the individual endpoint. Audio streams may exclude the voice of the user associated with the endpoint to which the audio stream is sent. However, the voice of this user can be included in all other audio streams. Audio module **720** can be adapted to analyze the received audio signals from the endpoints and determined the energy of each audio signal. Information on the signal energy can be transferred to the control module **740**. The energy level can be used as a selection parameter for selecting appropriate one or more endpoints as the source of the mixing of the audio and/or the video of the conference. The endpoints can be referred as selected endpoints or presented endpoints.

Video module **750** receives compressed video streams from the plurality of endpoints (not shown in FIG. **6**), which are sent toward the centralized entity **700** via a relevant network (not shown in the figures) and processed by network interface **710**. Video module **750** can create one or more compressed CP video images according to one or more layouts that are associated with one or more conferences currently being conducted by the centralized entity **700**. An example of video module **750** can have a plurality of input modules **751**A-C, a plurality of output modules **755***a-c* and a video common interface **754**. Each input module **751**A-C can be associated with an endpoint. Each output module **755**A-C can be associated with one or more endpoints that can receive and process a similar CP video image.

Control module **740** can be a logical unit that controls the operation of the centralized entity **700** using control lines **744**. In addition to common operation of a typical centralized entity **700**, centralized entity **700** is capable of additional functionality as result of having control module **740**.

Returning now to describe the elements of the video module **750** of the exemplary centralized entity **700**. Exemplary input module **751**A-C can include among other elements a decoder **752**. The decoder **752** receives compressed video from an associated endpoint. An associated endpoint is an endpoint that is associated with the relevant input module **751**. The decoder **752** decodes the compressed video into decoded video data. The decoded information is stored in a decoder frame memory from which it is transferred toward one or more output modules **755**A-C via common interface **754**.

Among other elements, an exemplary output module **755**A-C may include an encoder **758**.

In some embodiments the centralized entity **700** can be configured to deliver the presented CP video image. The presented CP video image complies with the parameters of a display unit of a receiving endpoint (REP).

Data in a frame memory can be encoded (compressed) by the encoder **758**. The compression can comply with the compression standard and parameters as defined during negotiation with the REP. The common interface **754** may include any of a variety of interfaces, such as but not limited to shared memory, ATM bus, TDM bus, switching and direct connection, etc. ATM stands for Asynchronous Transfer Mode, TDM stands for time division multiplexing.

FIG. **8** illustrates a block diagram with relevant elements of example embodiments of an audio-video endpoint **800**. The illustrated example of endpoint **800** is adapted to process a receiving compressed video image from an centralized entity **700**. An example embodiment of endpoint **800** may comprise one or more processors, computer readable medium such as a read/write hard disc, CDROM, Flash memory, ROM, or other memory or storage devices, etc. Software of a logical module may be embodied on one of the computer readable medium. In order to execute a certain task, a software program may be loaded to an appropriate processor as needed.

The endpoint **800** is capable of obtaining the compressed video image, decoding the compressed video, and processing the decoded data of the video image in order to create a presented CP video image. The presented CP video image can be delivered to the display unit (not shown in the drawings) of the endpoint **800**.

An example of endpoint **800** can comprise a network interface (NI) **810**, an audio module **820**, a control module **840**, and a video module **850**. The NI **810** can communicate with a centralized entity **700** or another endpoint **800** via one or more networks (not shown in the figures). Network interface **810** processes the communication according to one or more variety of communication standards such as but not limited to H.320, H.323, SIP, etc. and compression standards such as H.261, H.263, H.264, G.711, G.722; MPEG etc. Network interface **810** can receive and transmit control and data information to/from the centralized entity **700** or other endpoints **800**. More information concerning the communication between the endpoint and the centralized entity **700** or other endpoints **800** over the relevant network and information that describing signaling, control, compression, and setting a video call can be found in the international telecommunication union (ITU) standards H.320, H.321, H.323, H.261, H.263 and H.264.

Network interface module **810** multiplexes/de-multiplexes the different signals, media and/or "signaling and control," that are communicated between the endpoint and the centralized entity **700** or the endpoint **800** and other endpoints **800**. The compressed audio signal is transferred to and from the audio module **820**. The compressed video signal is transferred to and from video module **850** and the "control and signaling" is transferred to and from control module **840**.

Audio module **820** may receive, via network interface **810** and the audio line, compressed mixed audio stream from the centralized entity **700** or another endpoint **800**. The audio module **820** decodes the compressed mixed audio stream, amplifies it, and transfers the decoded mixed audio stream toward the one or more loudspeakers (not shown) of the endpoint **800**. In the other direction, the audio module **820** may process the audio that is obtained from the user of endpoint **800** by a microphone (not shown in the figures), compresses the audio signal, and sends the compressed audio toward the centralized entity **700** or other endpoint **800** via NI **810**.

Control module **840** can be a logical unit that controls the operation of the endpoint **800**. In addition to common operation of a typical endpoint, endpoint **800** is capable of additional functionality as result of having control module **840**.

Some embodiment of video module **850** may comprise, among other elements, an encoder **851**, a decoder **853**, and a CP frame memory (CPFM) **859**. An embodiment of CPFM **859** can be a cyclic buffer that is adapted to store decoded video data of at least two frames of the presented video stream. A completed frame from the CPFM **859** can be transferred toward a display unit of the endpoint **800** to be presented to the user of the endpoint **800**.

The above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments may be used in combination with each other. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein."

I claim:

1. An endpoint device for a videoconferencing system, comprising:

a network interface;

an audio module, configured to receive an audio stream from the network interface and to send an audio stream to the network interface;

a video module, configured to receive a video stream from the network interface and to send a video stream to the network interface; and

a control module configured to manage mesh connections between the endpoint device and other endpoint devices and to manage connections between the endpoint and a centralized entity,

wherein the control module is configured to cause the endpoint device to:

establish mesh connections with a plurality of other endpoints via the network interface;

establish a connection with a centralized entity via the network interface;

send a main video stream from the video module to the centralized entity via the network interface;

receive low bandwidth video streams from non-speaker endpoints of the plurality of endpoints via the mesh connections; and

receive a high resolution video stream associated with an active speaker from the centralized entity.

2. The endpoint of claim **1**,

wherein the low bandwidth video streams comprise low resolution video streams.

3. The endpoint of claim **1**,

wherein the endpoint corresponds to a non-speaker, and

wherein the control module is further configured to cause the endpoint device to send a low bandwidth video stream to the plurality of endpoints from the video module via the mesh connections.

4. The endpoint of claim **3**,

wherein the low bandwidth video streams comprise low resolution video streams.

5. The endpoint of claim **1**, wherein the control module is further configured to cause the endpoint device to:

send a main audio stream from the audio module to the plurality of endpoints via the mesh connections.

6. The endpoint of claim **5**, wherein the control module is further configured to cause the endpoint device to:

send the main audio stream from the audio module to the centralized entity.

7. The endpoint of claim **1**, wherein the control module is further configured to cause the endpoint device to:

send a main audio stream from the audio module to the centralized entity; and

receive a mixed audio stream from the centralized entity corresponding to at least some of the plurality of endpoints.

8. A non-transitory machine readable medium, on which are stored instruction, comprising instructions that when executed cause an endpoint device to:

establish mesh connections with a plurality of other endpoints via a network interface of the endpoint device;

establish a connection with a centralized entity via the network interface;

send a main video stream from a video module of the endpoint device to the centralized entity via the network interface;

receive low bandwidth video streams from non-speaker endpoints of the plurality of endpoints via the mesh connections; and

receive a high resolution video stream associated with an active speaker from the centralized entity.

9. The machine readable medium of claim **8**, wherein the low bandwidth video streams comprise low resolution video streams.

10. The machine readable medium of claim **8**, wherein the instructions further comprise instructions that when executed cause the endpoint device to:

send a low bandwidth video stream to the plurality of endpoints via the mesh connections when the endpoint device corresponds to a non-speaker.

11. The machine readable medium of claim **10**, wherein the low bandwidth video streams comprise low resolution video streams.

12. The machine readable medium of claim **8**, wherein the instructions further comprise instructions that when executed cause the endpoint device to:

send a main audio stream from an audio module of the endpoint device to the centralized entity; and

send the main audio stream to the plurality of endpoints via the mesh connections.

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